FIG. 1

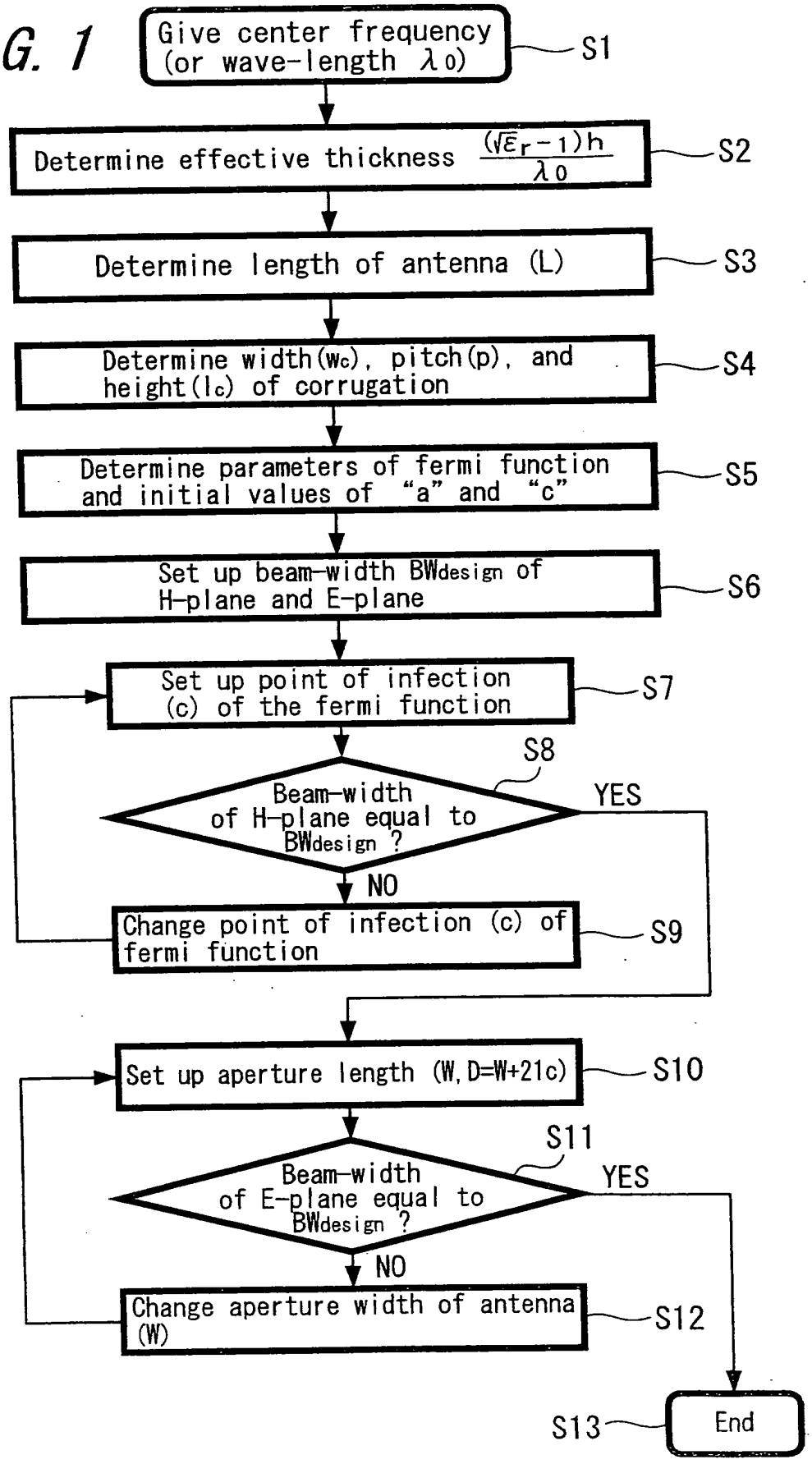
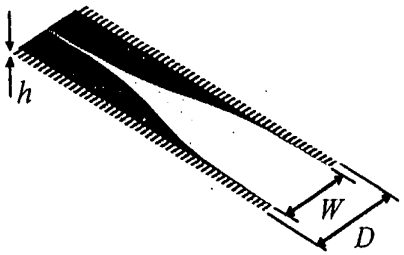

Give center frequency (or wave-length λ0)
S1
Determine effective thickness (√εr − 1)h / λ0
S2
Determine length of antenna (L)
S3
Determine width(wc), pitch(p), and height(lc) of corrugation
S4
Determine parameters of fermi function and initial values of "a" and "c"
S5
Set up beam-width BWdesign of H-plane and E-plane
S6
Set up point of infection (c) of the fermi function
S7
S8
Beam-width of H-plane equal to BWdesign ?
YES
NO
Change point of infection (c) of fermi function
S9
Set up aperture length (W, D=W+21c)
S10
S11
Beam-width of E-plane equal to BWdesign ?
YES
NO
Change aperture width of antenna (W)
S12
S13
End

FIG. 2

$\varepsilon_r = 3.7$ $\quad h = 0.1, 0.2, 0.5\text{mm}$

$\varepsilon_r = 9.8$ $\quad h = 0.05, 0.1, 0.2\text{mm}$



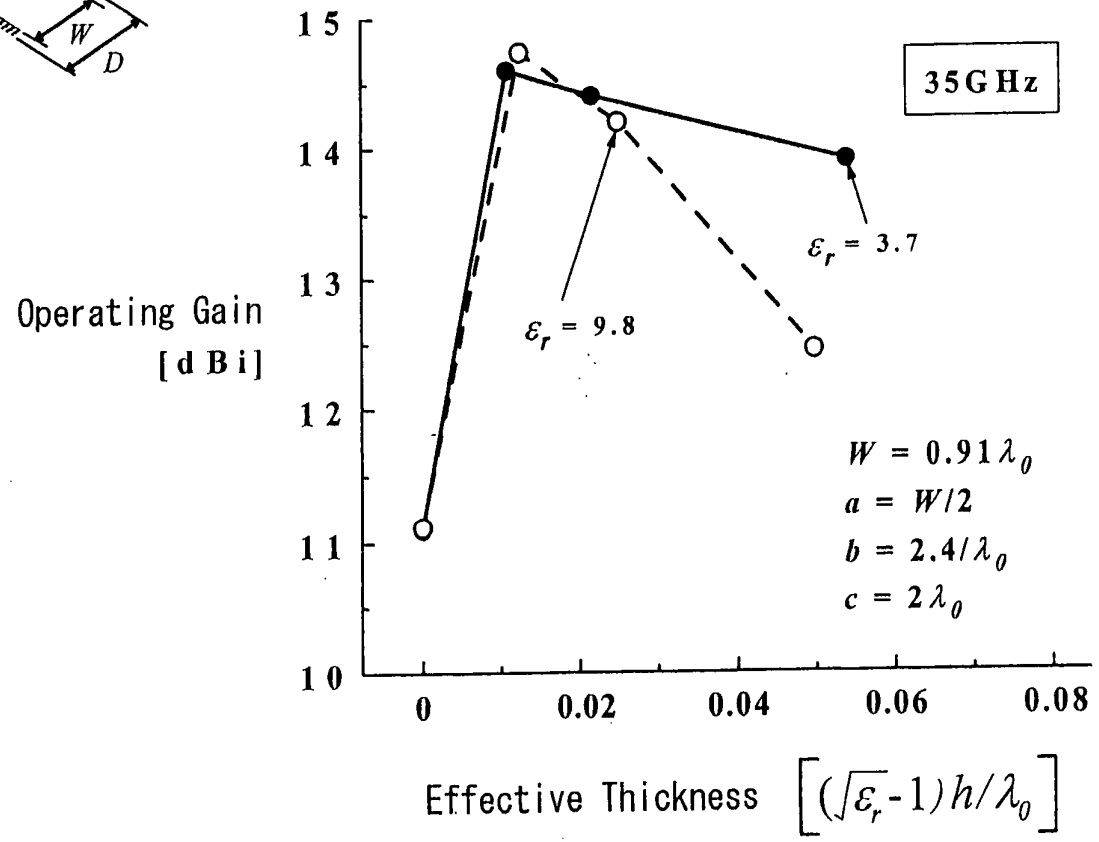


FIG. 3

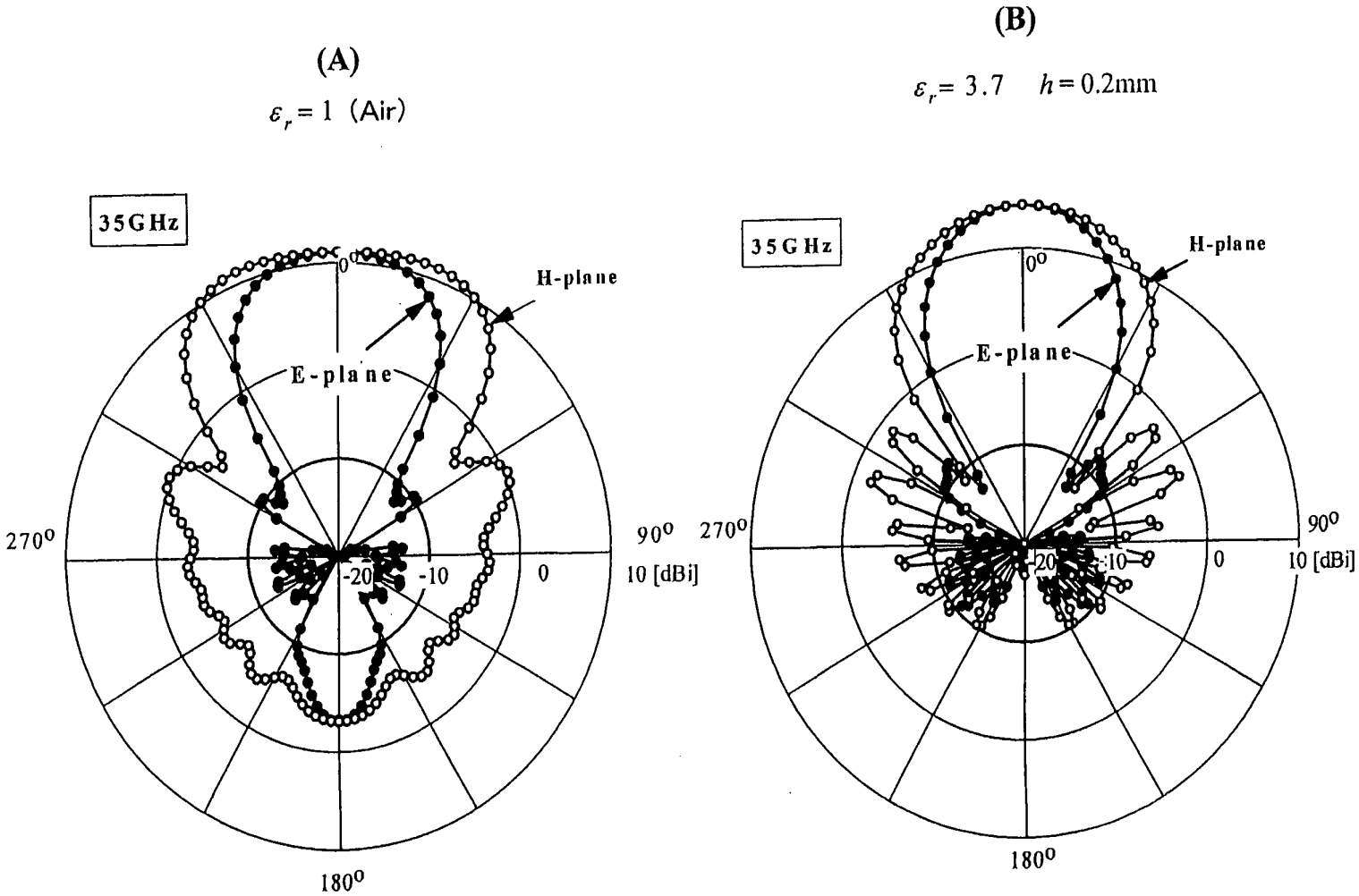

(A)
$\varepsilon_r = 1$ (Air)
35GHz
H-plane
E-plane
0°
90°
180°
270°
-20
-10
0
10 [dBi]
(B)
$\varepsilon_r = 3.7$ $h = 0.2$mm
35GHz
H-plane
E-plane
0°
90°
180°
270°
-20
-10
0
10 [dBi]

FIG. 4

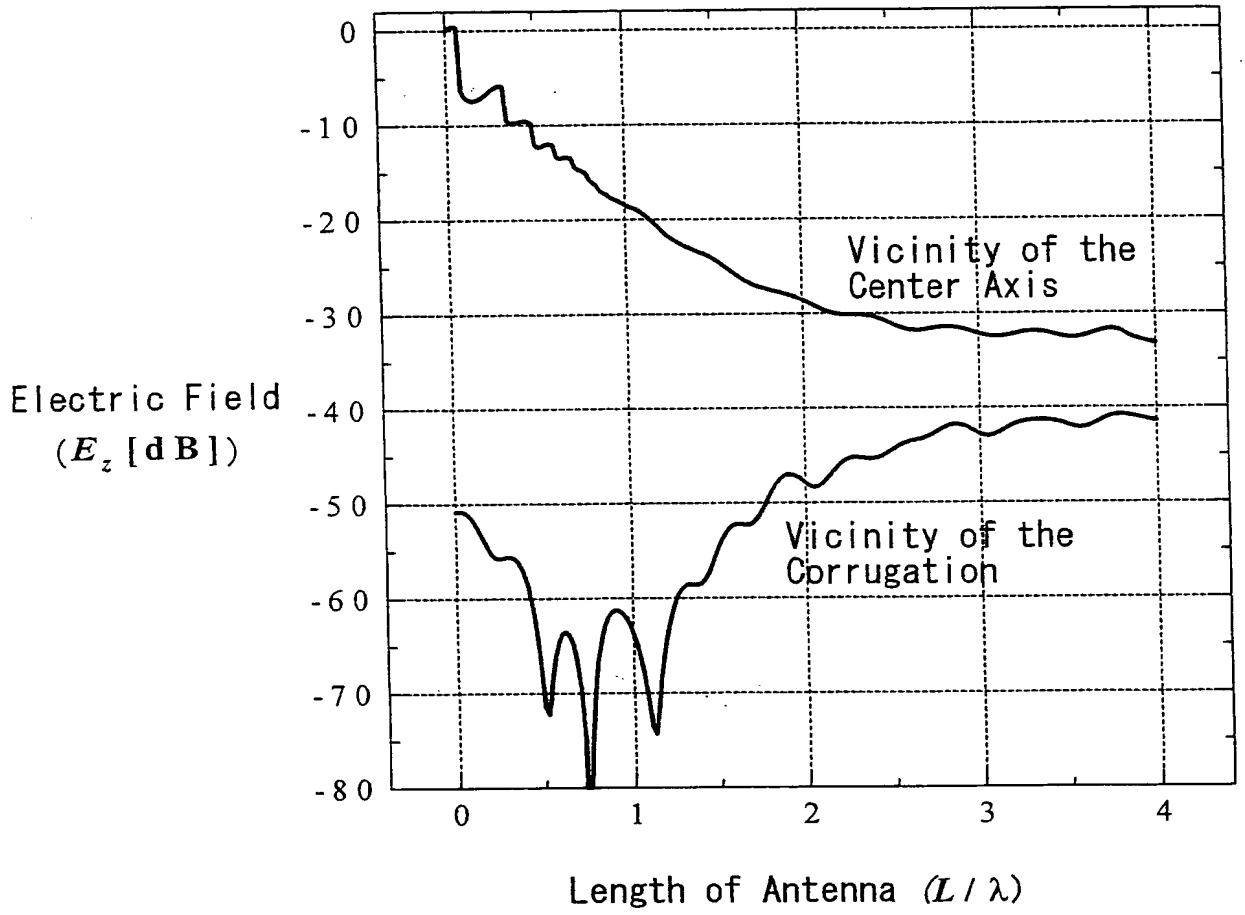

Electric Field
(E_z [dB])
0
-10
-20
-30
-40
-50
-60
-70
-80
0
1
2
3
4
Vicinity of the Center Axis
Vicinity of the Corrugation
Length of Antenna (L / λ)

FIG. 5

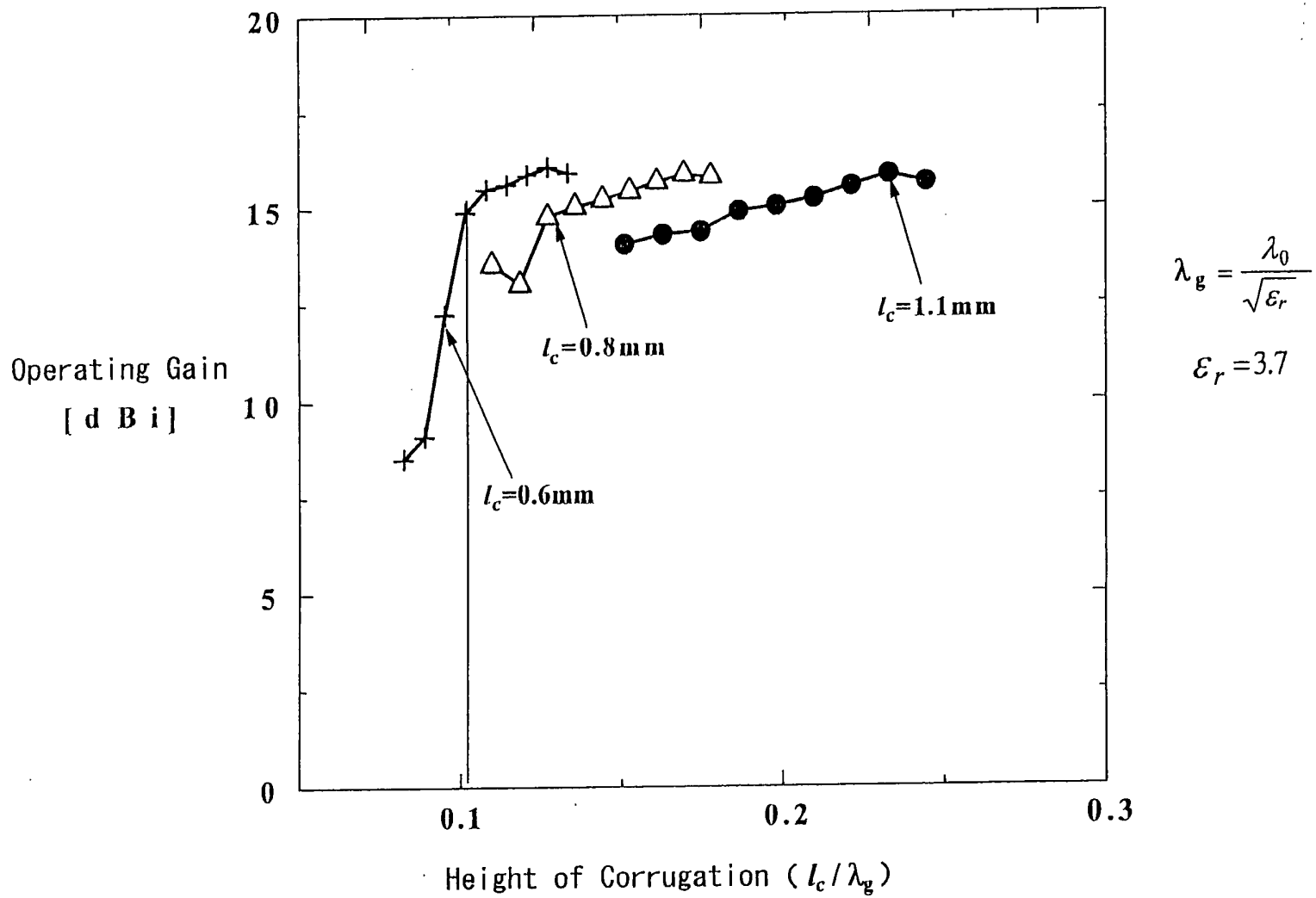

20
15
10
5
0
0.1
0.2
0.3
Operating Gain
[dBi]
l_c=0.6mm
l_c=0.8mm
l_c=1.1mm
Height of Corrugation (l_c/λ_g)
$\lambda_g = \frac{\lambda_0}{\sqrt{\varepsilon_r}}$
ε_r=3.7

FIG. 6

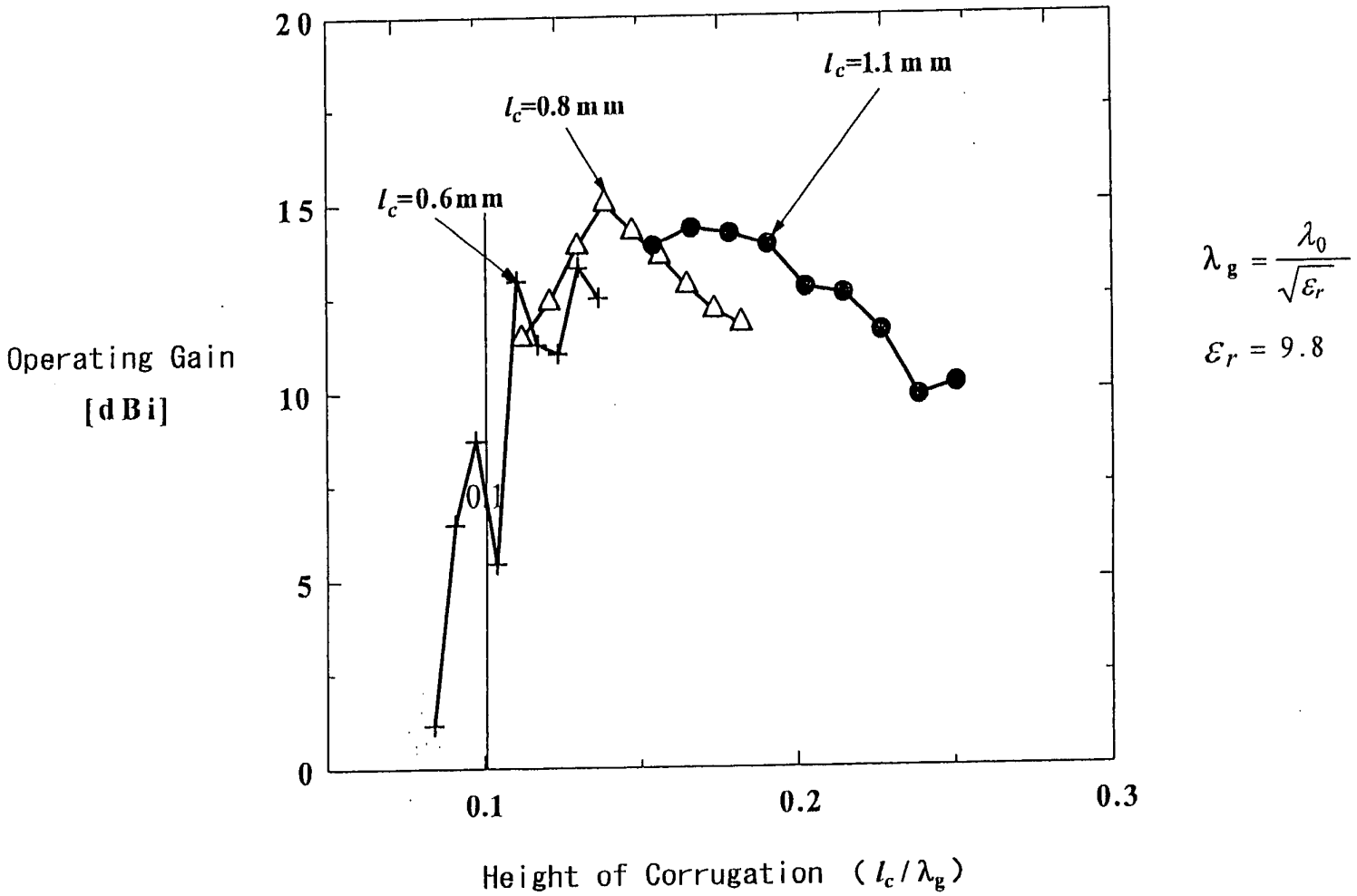
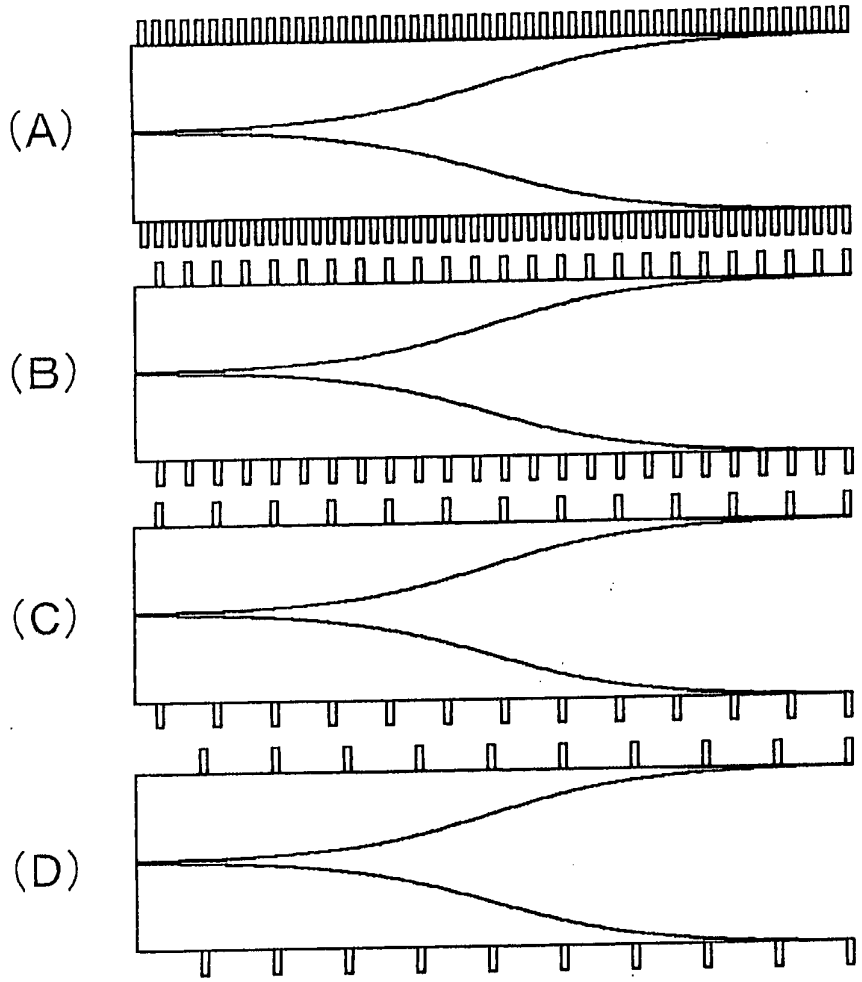
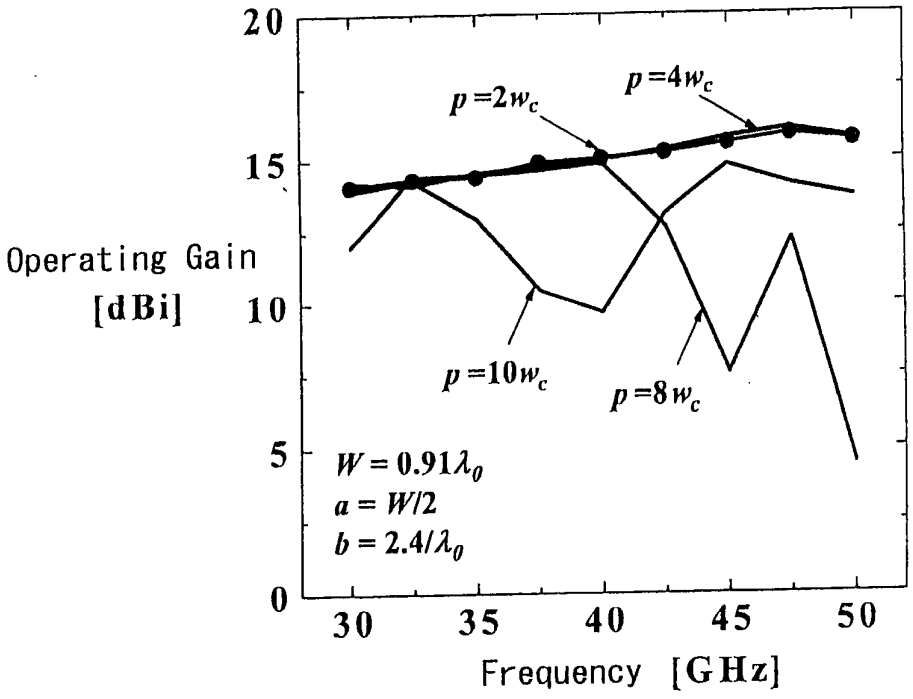

20
15
10
5
0
0.1
0.2
0.3
l_c=1.1 mm
l_c=0.8 mm
l_c=0.6mm
Operating Gain
[dBi]
Height of Corrugation (l_c/λ_g)
$\lambda_g = \frac{\lambda_0}{\sqrt{\varepsilon_r}}$
ε_r = 9.8

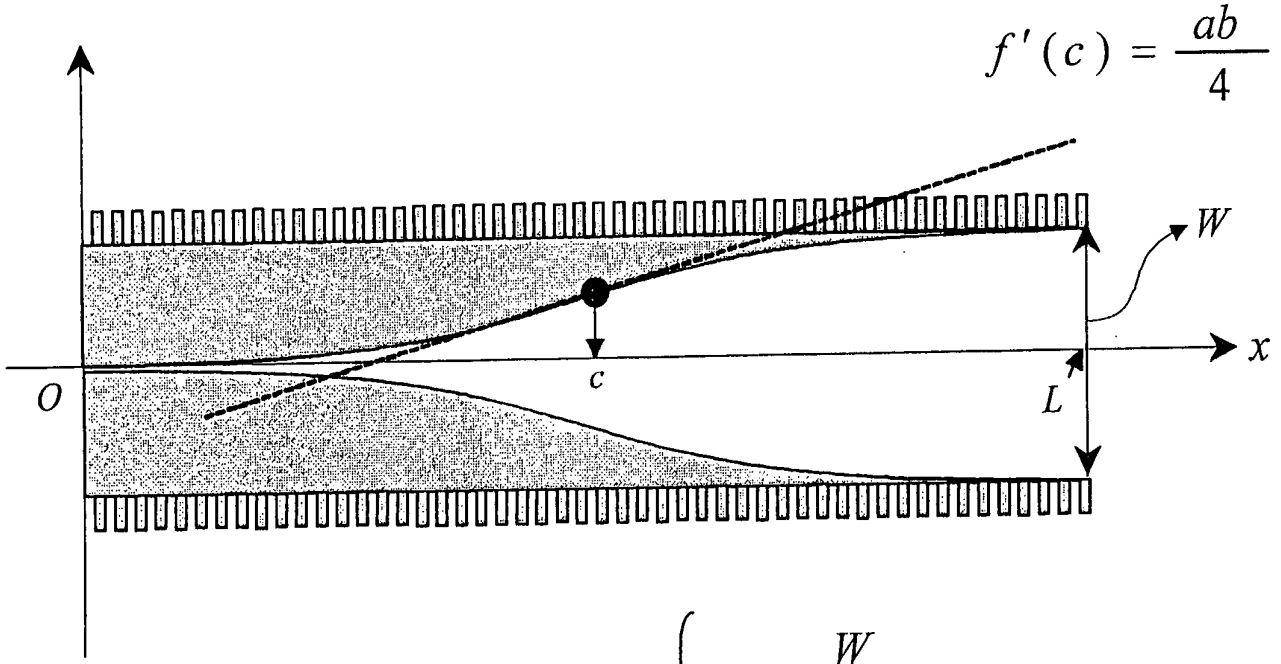
FIG. 7


(A)
(B)
(C)
(D)


Operating Gain
[dBi]
20
15
10
5
0
30
35
40
45
50
Frequency [GHz]
p=2w_c
p=4w_c
p=10w_c
p=8w_c
W = 0.91λ_0
a = W/2
b = 2.4/λ_0

(E)

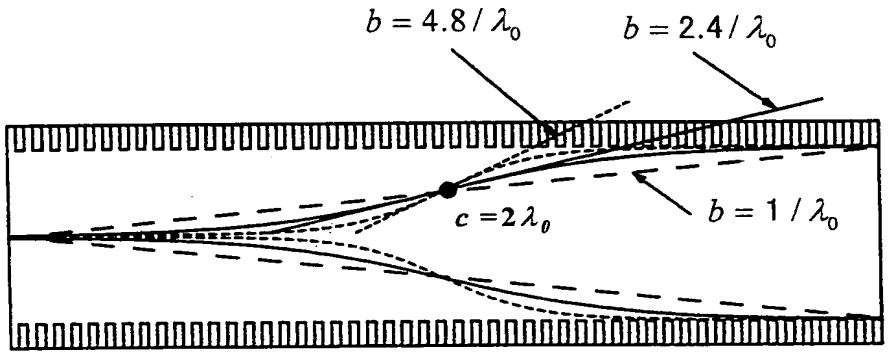
FIG. 8



$$f(x) = \frac{a}{1 + e^{-b(x-c)}} \begin{cases} a = \frac{W}{2} \\ b = \frac{4}{a} f'(c) \end{cases}$$

FIG. 9

(A)


$b = 4.8/\lambda_0$
$b = 2.4/\lambda_0$
$c = 2\lambda_0$
$b = 1/\lambda_0$

(B)

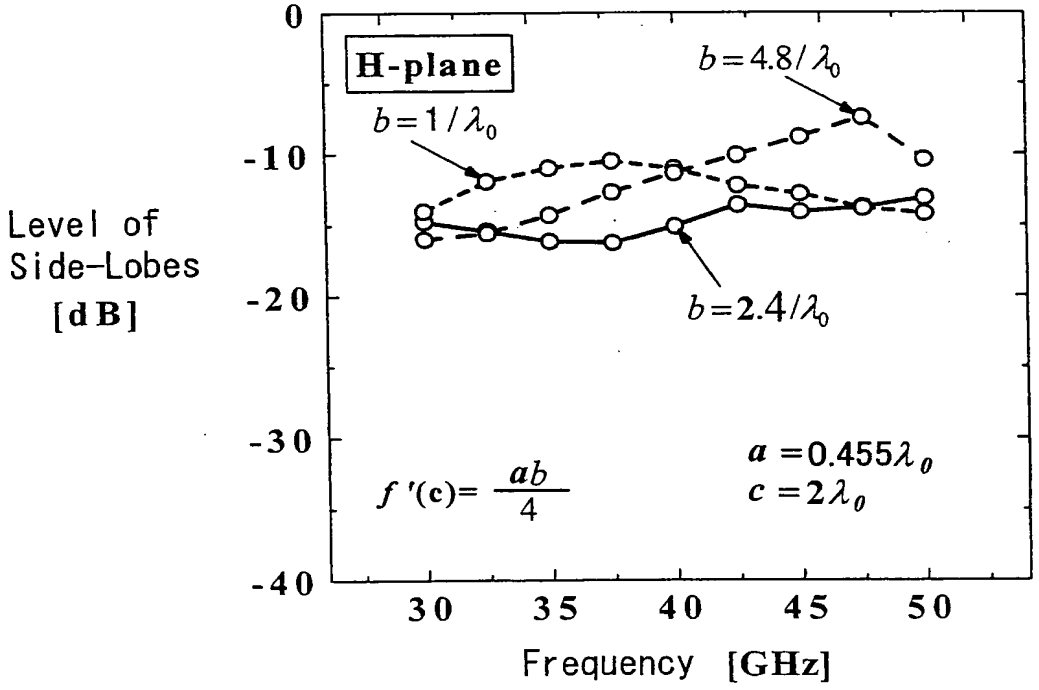
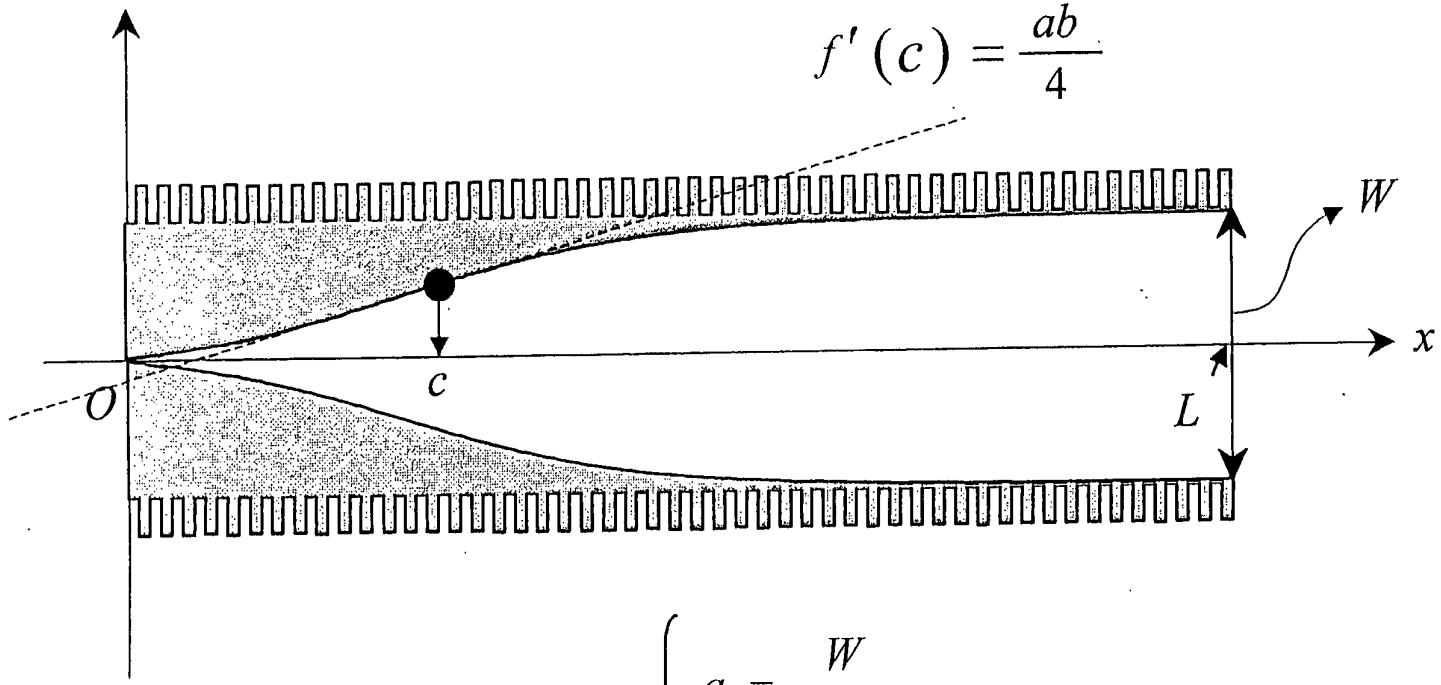

0
-10
-20
-30
-40
H-plane
$b=4.8/\lambda_0$
$b=1/\lambda_0$
$b=2.4/\lambda_0$
$f'(c)=\frac{ab}{4}$
$a=0.455\lambda_0$
$c=2\lambda_0$
30
35
40
45
50
Frequency [GHz]
Level of Side-Lobes [dB]

FIG. 10



$$f(x) = \frac{a}{1 + e^{-b(x-c)}} \begin{cases} a = \frac{W}{2} \\ b = \frac{4}{a} f'(c) \end{cases}$$

FIG. 11

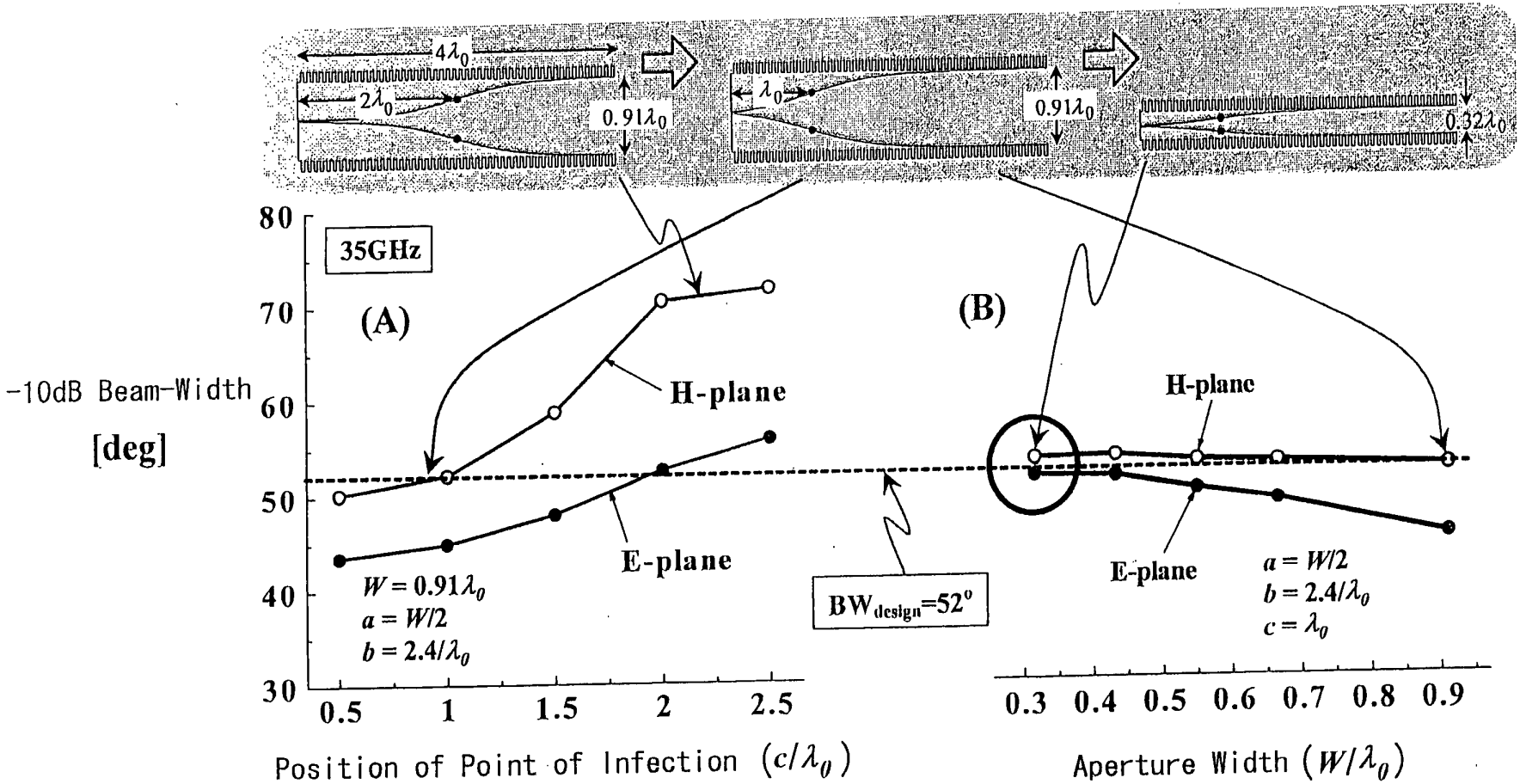
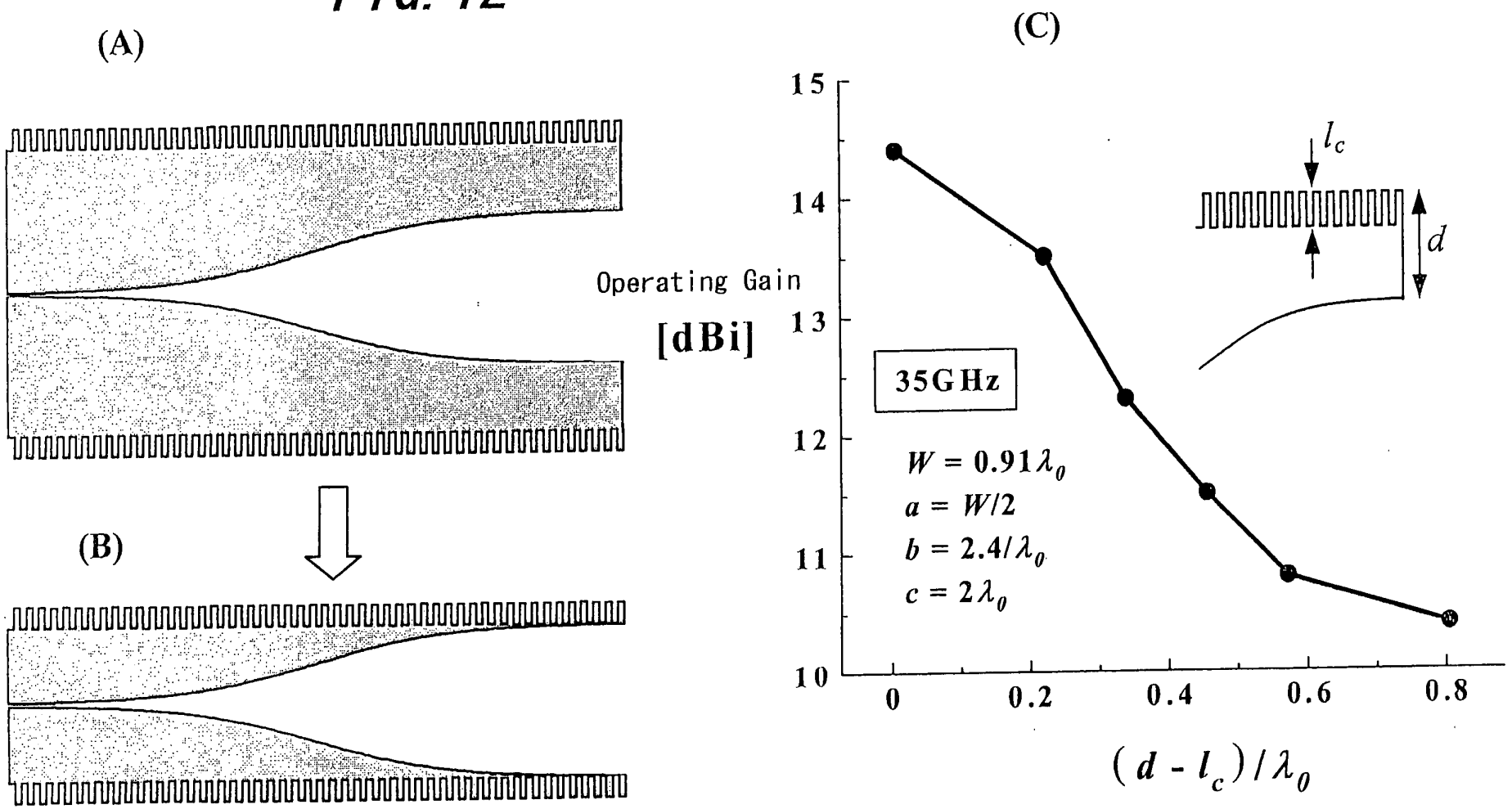

4λ0
2λ0
0.91λ0
λ0
0.91λ0
0.32λ0
80
70
60
50
40
30
35GHz
(A)
(B)
H-plane
E-plane
H-plane
E-plane
W = 0.91λ0
a = W/2
b = 2.4/λ0
BWdesign=52°
a = W/2
b = 2.4/λ0
c = λ0
-10dB Beam-Width
[deg]
0.5
1
1.5
2
2.5
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Position of Point of Infection (c/λ0)
Aperture Width (W/λ0)

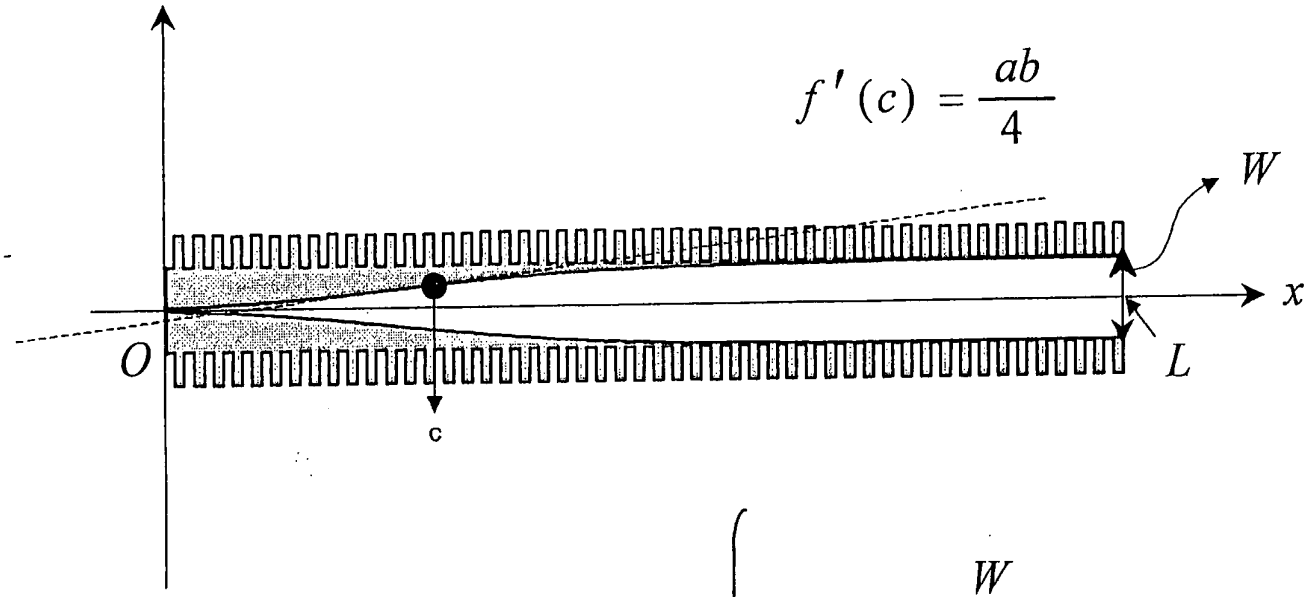
FIG. 12



Condition That Gives High Gain

$$d = l_c$$

FIG. 13



$$f(x) = \frac{a}{1 + e^{-b(x-c)}} \begin{cases} a = \frac{W}{2} \\ f'(c) = \frac{ab}{4} \end{cases}$$

FIG. 14

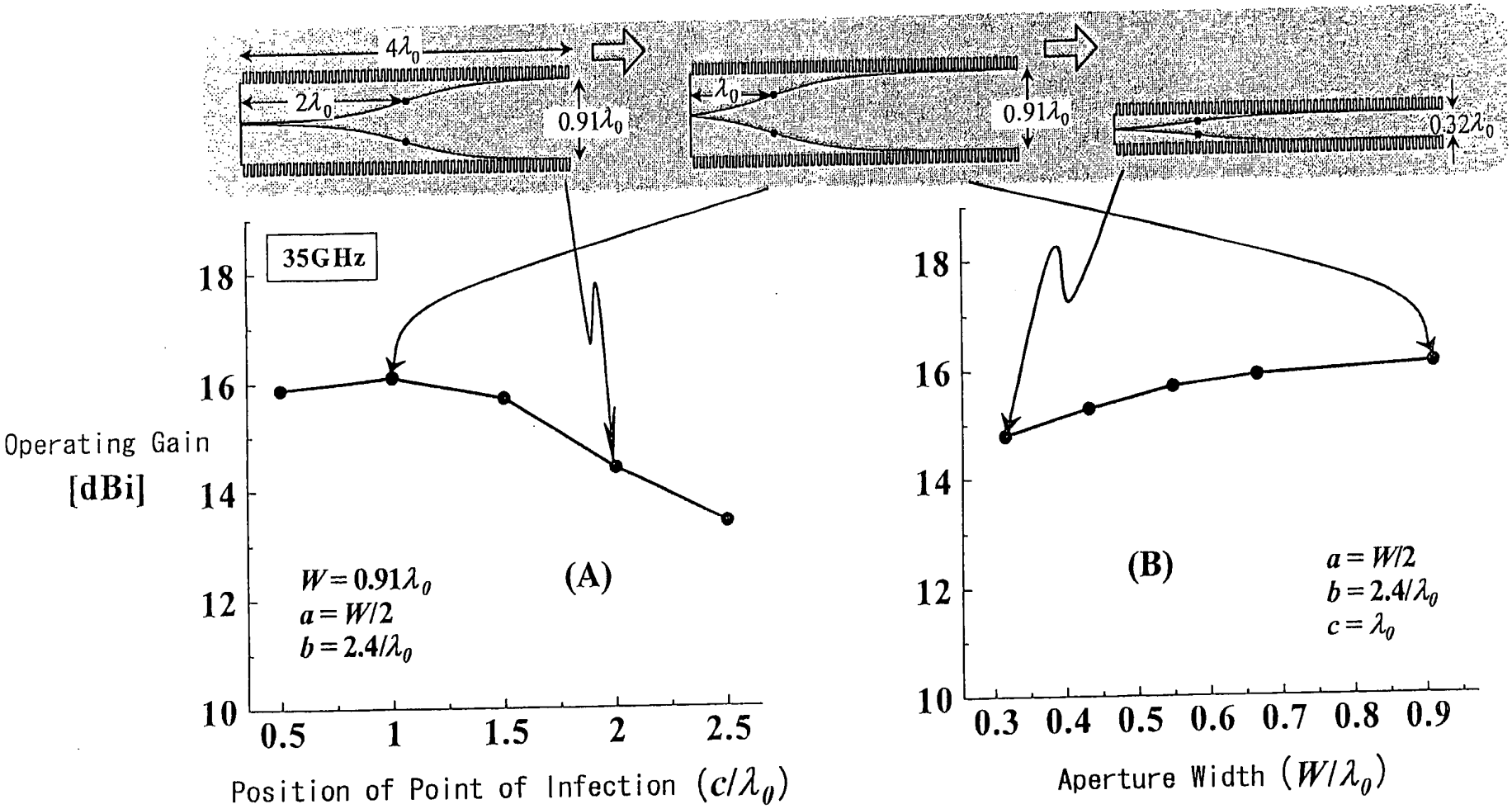
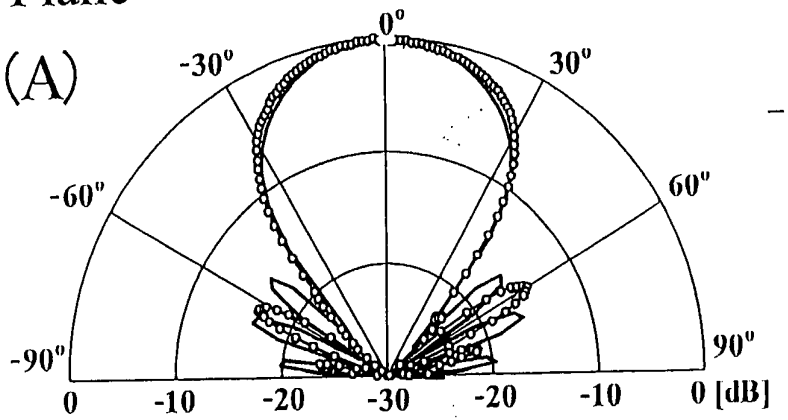

$4\lambda_0$
$2\lambda_0$
$0.91\lambda_0$
λ_0
$0.91\lambda_0$
$0.32\lambda_0$
35GHz
Operating Gain
[dBi]
18
16
14
12
10
0.5
1
1.5
2
2.5
$W = 0.91\lambda_0$
$a = W/2$
$b = 2.4/\lambda_0$
(A)
Position of Point of Infection (c/λ_0)
(B)
$a = W/2$
$b = 2.4/\lambda_0$
$c = \lambda_0$
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Aperture Width (W/λ_0)

FIG. 15

35GHz

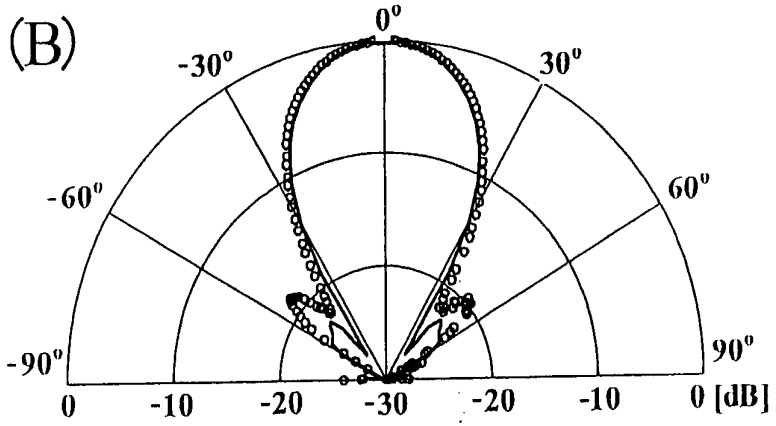
H-Plane

(A)



E-Plane

(B)



(C)

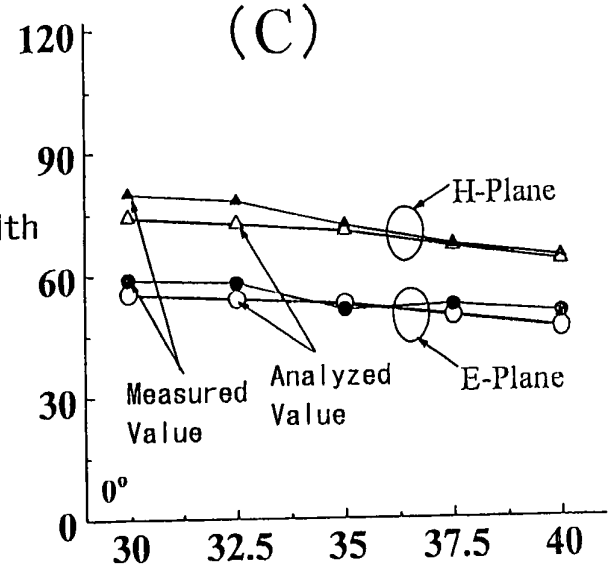
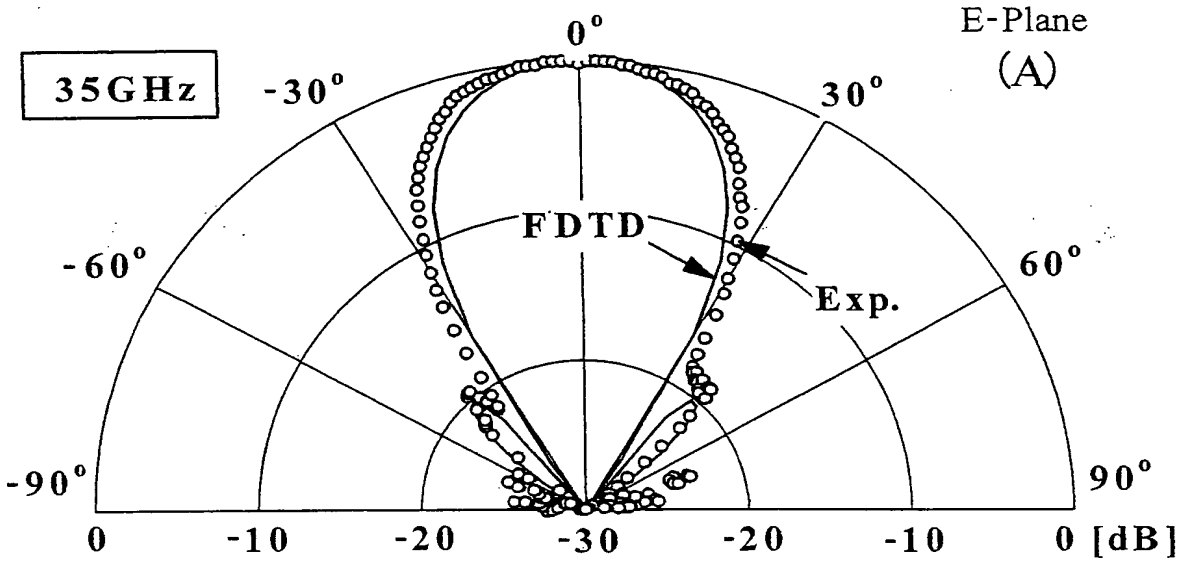


FIG. 16


35GHz
0°
-30°
30°
-60°
60°
-90°
90°
FDTD
Exp.
0
-10
-20
-30
-20
-10
0 [dB]
E-Plane
(A)

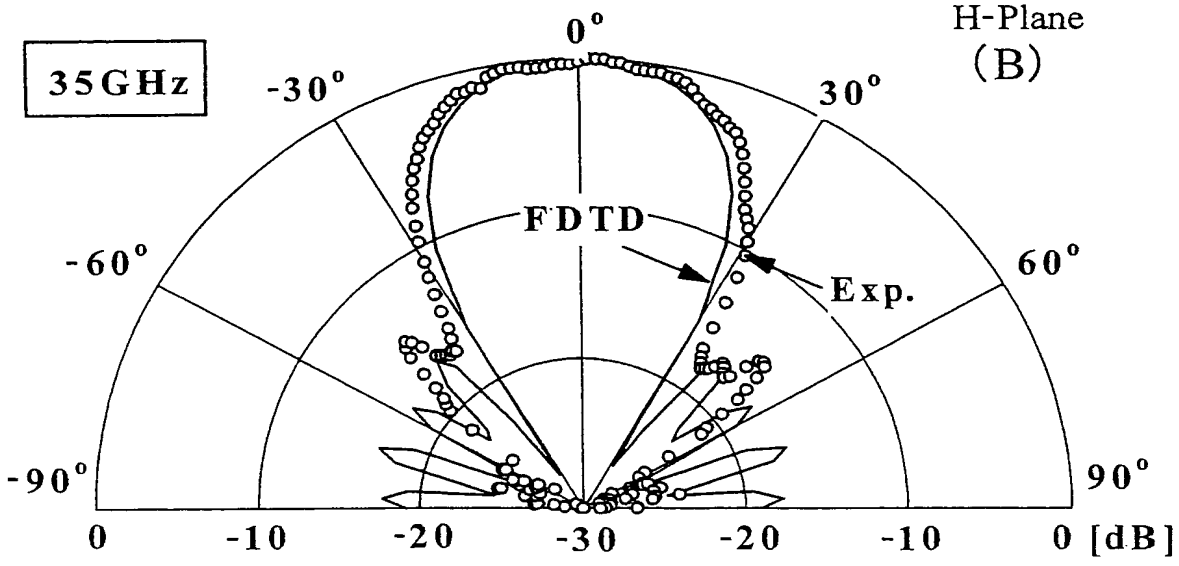
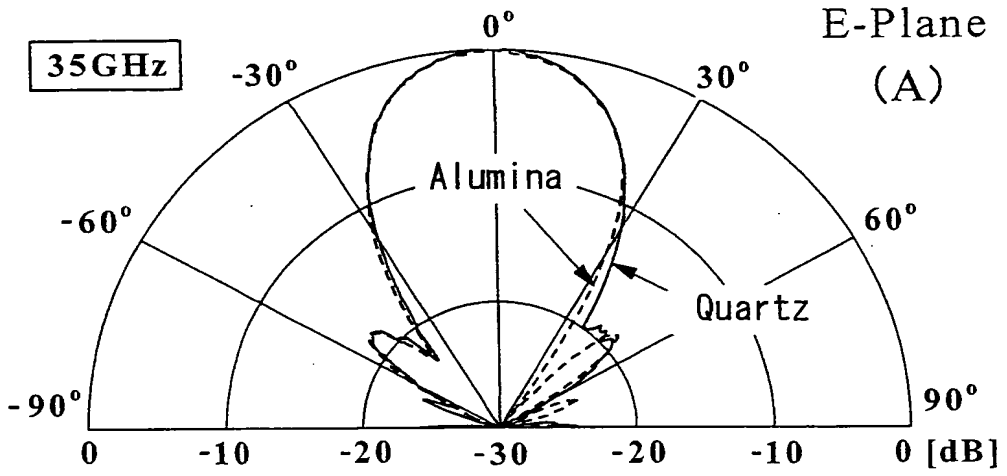

35GHz
0°
-30°
30°
-60°
60°
-90°
90°
FDTD
Exp.
0
-10
-20
-30
-20
-10
0 [dB]
H-Plane
(B)

FIG. 17


35GHz
0°
-30°
30°
-60°
60°
-90°
90°
Alumina
Quartz
0
-10
-20
-30
-20
-10
0 [dB]
E-Plane
(A)

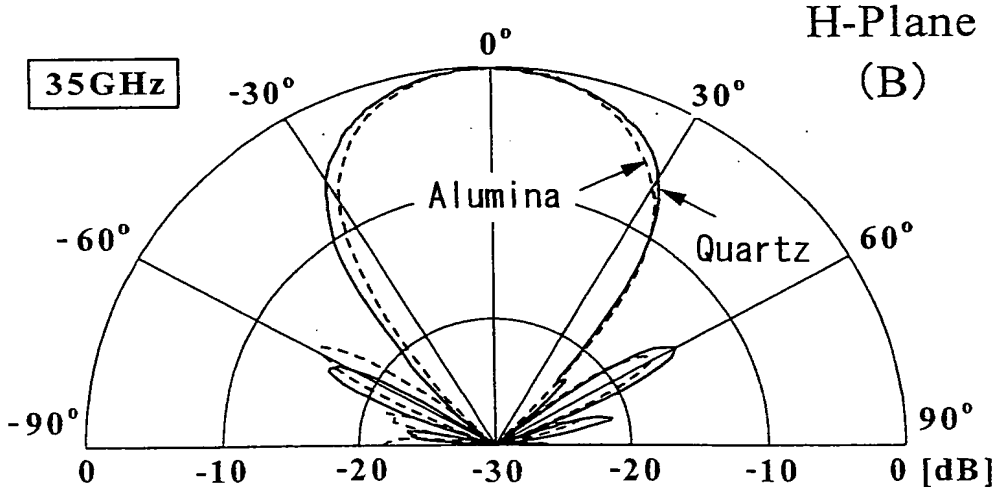
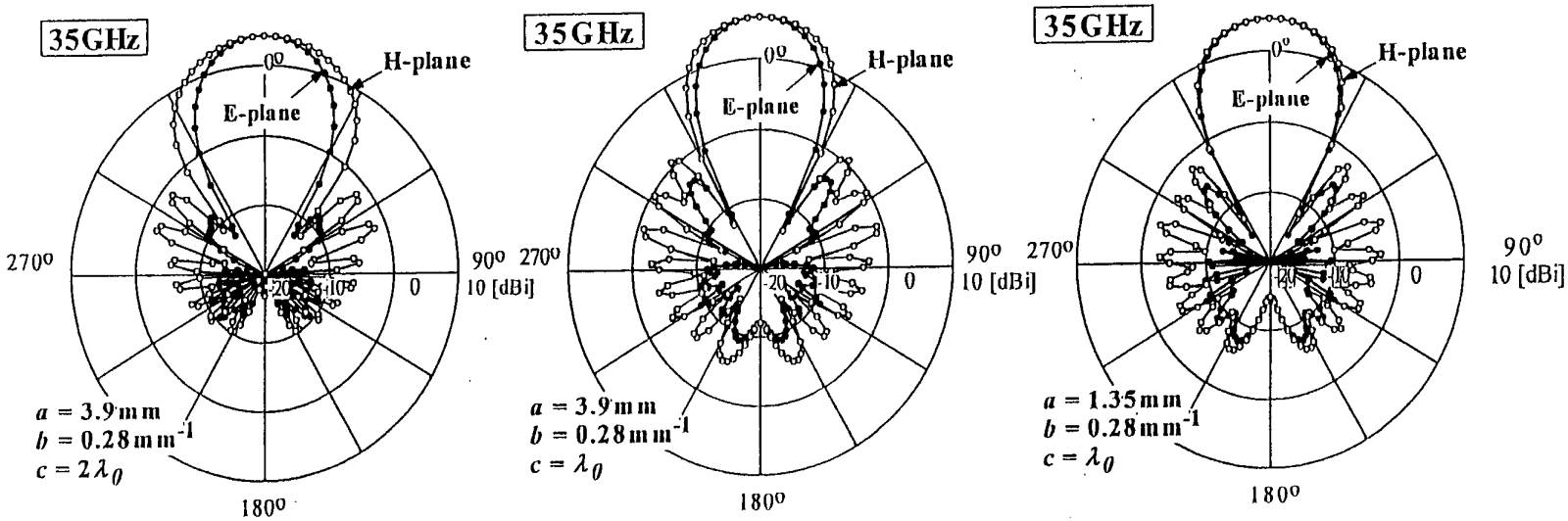

35GHz
0°
-30°
30°
-60°
60°
-90°
90°
Alumina
Quartz
0
-10
-20
-30
-20
-10
0 [dB]
H-Plane
(B)

FIG. 18

Position of Point of Infection Decreasing (Beam-Width of H-Plane Decreasing)

Aperture Width Decreasing (Beam-Width of E-Plane Increasing)



Operating Gain 14.8 dBi

Side-Lobes Level of E-Plane -20.2 dB

Side-Lobes Level of H-Plane -16.8 dB

FIG. 19

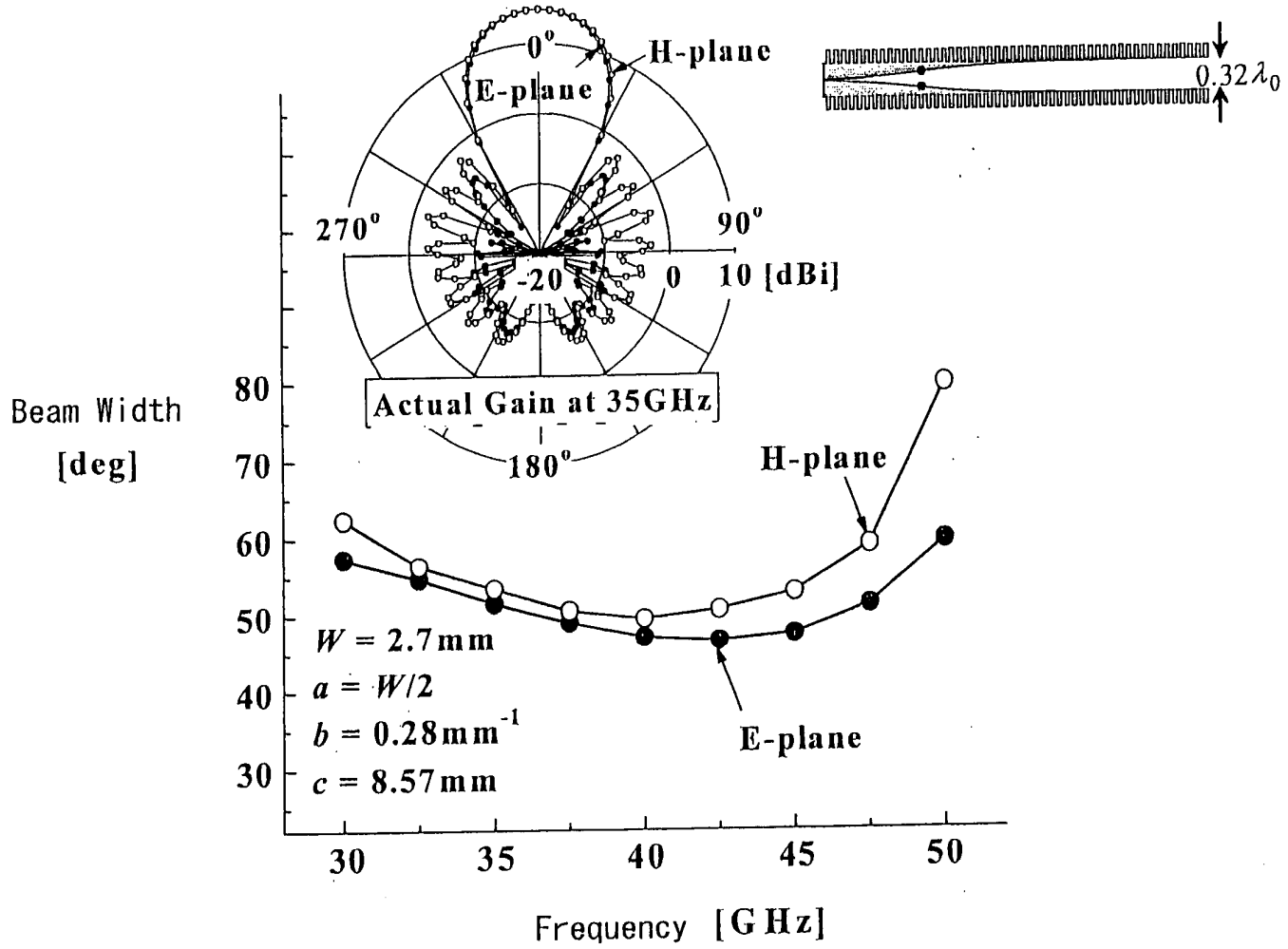

0°
H-plane
E-plane
270°
90°
-20
0
10 [dBi]
Actual Gain at 35GHz
180°
0.32λ0
Beam Width
[deg]
80
70
60
50
40
30
H-plane
E-plane
W = 2.7mm
a = W/2
b = 0.28mm-1
c = 8.57mm
30
35
40
45
50
Frequency [GHz]

FIG. 20

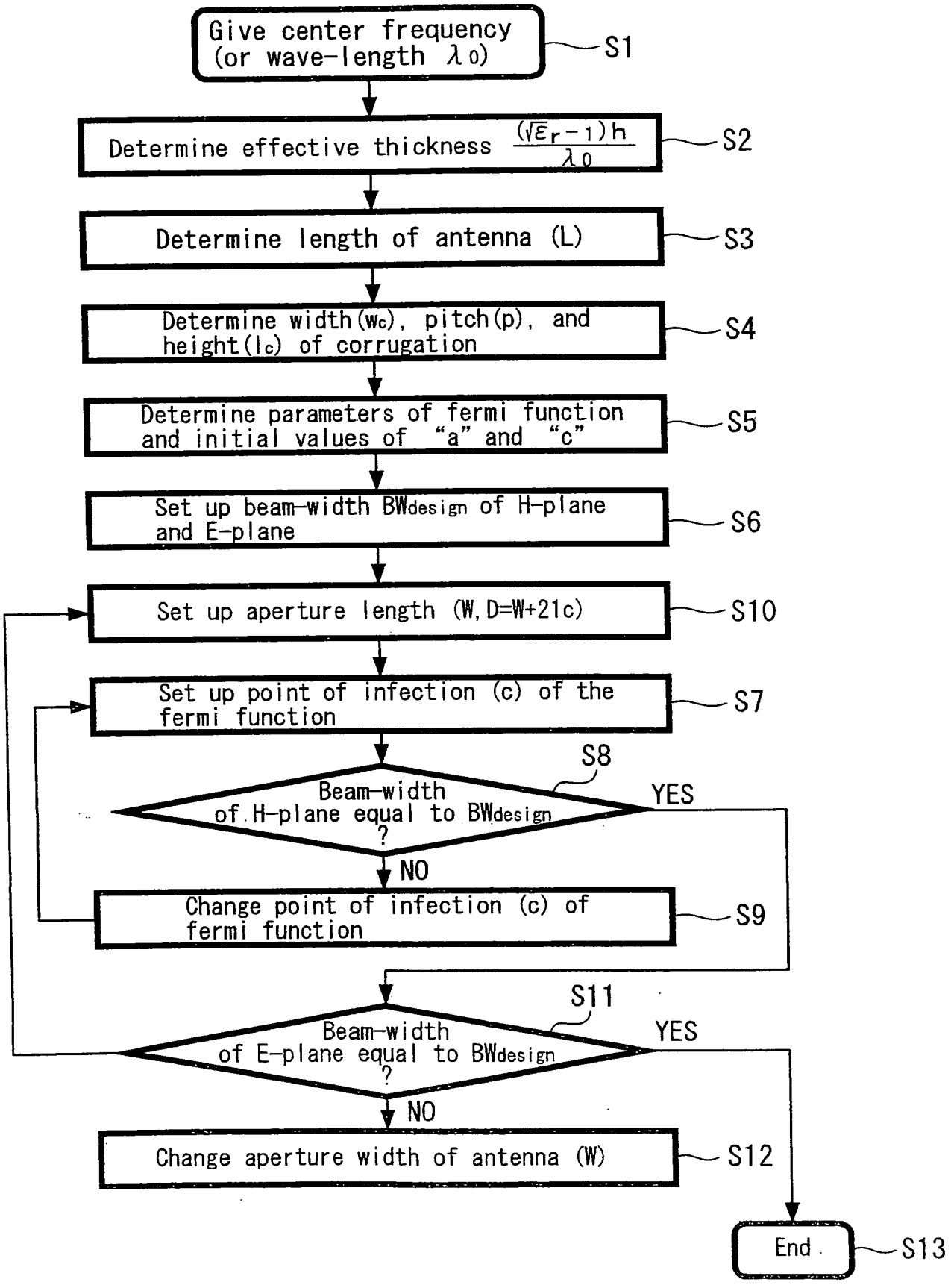

Give center frequency (or wave-length λ0)
S1
Determine effective thickness $\frac{(\sqrt{\varepsilon_r}-1)h}{\lambda_0}$
S2
Determine length of antenna (L)
S3
Determine width(wc), pitch(p), and height(lc) of corrugation
S4
Determine parameters of fermi function and initial values of "a" and "c"
S5
Set up beam-width BWdesign of H-plane and E-plane
S6
Set up aperture length (W, D=W+21c)
S10
Set up point of infection (c) of the fermi function
S7
S8
Beam-width of H-plane equal to BWdesign ?
YES
NO
Change point of infection (c) of fermi function
S9
S11
Beam-width of E-plane equal to BWdesign ?
YES
NO
Change aperture width of antenna (W)
S12
End
S13

FIG. 21

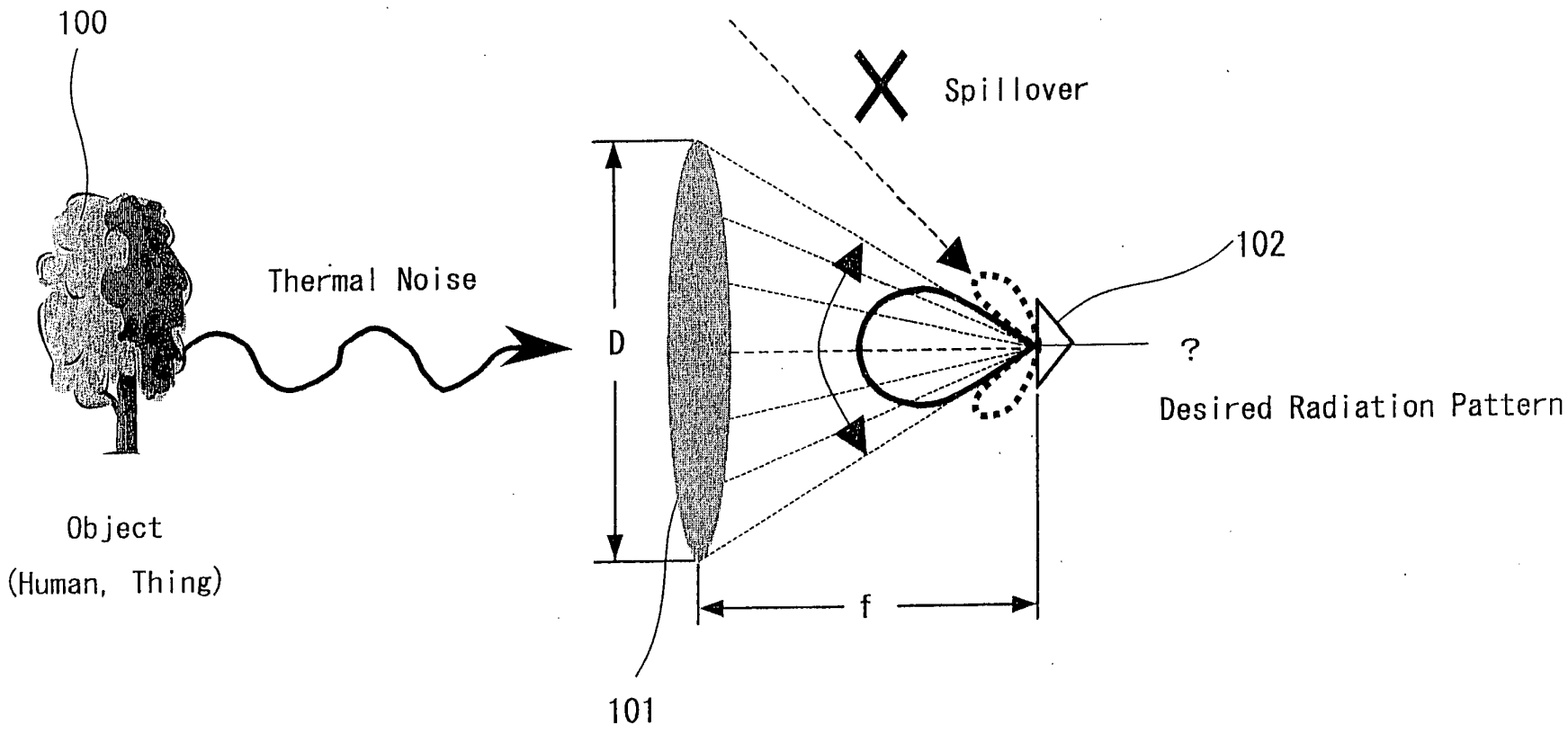

100
Thermal Noise
Object
(Human, Thing)
Spillover
D
102
?
Desired Radiation Pattern
f
101

FIG. 22

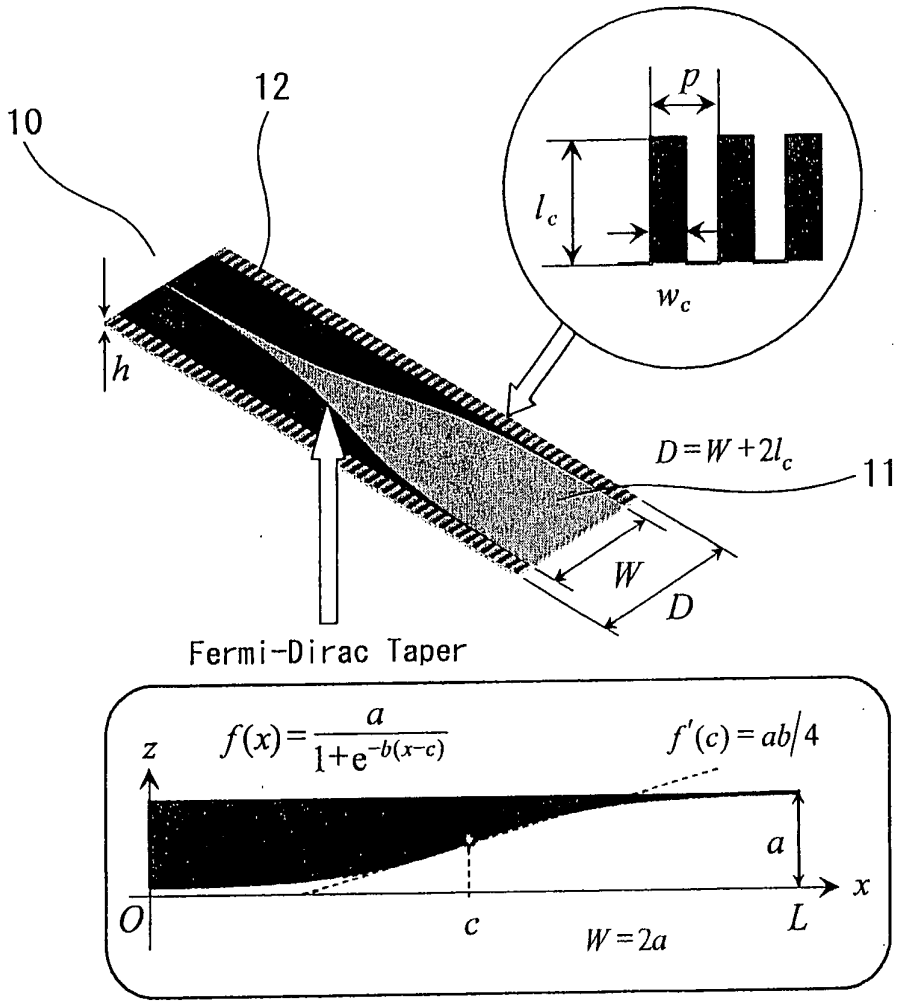

10
12
p
l_c
w_c
h
$D=W+2l_c$
11
W
D
Fermi-Dirac Taper
z
$f(x)=\frac{a}{1+e^{-b(x-c)}}$
$f'(c)=ab/4$
a
x
O
c
L
W=2a

FIG. 23

Name of Measures	[mm]	[λ_0]@35GHz
Length of Antenna L	34.28	4
Aperture Width W	7.8	0.91
Distance d Between End of Substrate And End of Aperture d	1.15	0.13
Substrate Width D	10.1	1.18
Substrate Thickness h	0.2	0.02
Corrugation Length lc	1.1	0.13
Corrugation Width w_c	0.3428	0.04
Corrugation Pitch P	0.6856	0.08
Slot Line Width w_s	0.1	0.01